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(54) Optical fiber switching apparatus

Schaltvorrichtung für optische Fibern

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- **IEICE TRANSACTIONS ON COMMUNICATIONS, vol.E75-B, no.12, December 1992, TOKYO JP pages 1373 - 1375 T.KATAGIRI ET AL. 'Cassette-Type Non-blocking 100X100 Optomechanical Matrix Switch'**
- **PATENT ABSTRACTS OF JAPAN vol. 13, no. 82 (P-833) (3430) 23 February 1989 & JP-A-63 264 718 (NIPPON TELEGR & TELEPH) 1 November 1988**

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an optical fiber switching apparatus that can be used in a coupling portion which performs operations such as switching for systems in which optical fibers are coupled so as to constitute a fiber optic network or the like.

2. Description of the Prior Art

Although an optical fibers have been used in trunk line communication systems, research aimed at introducing fiber optic network systems is currently being conducted. Unlike systems which repeat transfers from point to point, it is necessary for a fiber optic network system to provide superior serviceability and efficiency for the distributed users which are on the same level. In order to design such a fiber optic network system, it is important to provide a switching apparatus such as, for example, an optical cross-connection apparatus, an optical switch board, etc. for switching the optical fibers without adversely affecting the light signals transmitted therein.

Apparatuses such as the optical cross-connection apparatus are often referred to as "huge optical switches". Although various research is being conducted, it has proven difficult to develop a relatively small optical switch which has multiple inputs and multiple outputs. The difficulty arises because the number of coupled lines becomes large when optical fibers are coupled in a network. The optical fibers become so crowded that the working efficiency of the coupled optical fiber decreases drastically. It is also possible for the optical fibers to be misconnected. Moreover, the overcrowding of the optical fibers becomes even more severe when a coupling point is intended to be switched to another terminal.

A conventional optical switch which has been used for the aforementioned switching is a "1 × N" (i.e. single × plural) type optical switch. In a 1 × N type optical switch, a single-core connector is disposed on the "1-side" (i.e. single-side) while a plurality of single-core connectors are disposed on the "N-side" (i.e. plural-side) on the same level. Thus, the single-core connector on the 1-side is carried by a switching mechanism, thereby allowing the 1-side single-core connector to be coupled with a desired connector on the N-side.

Another conventional optical switch is a "N × M" (i. e. plural × plural) type optical switch. In an N × M type optical switch, a plurality of guide rails disposed in the direction perpendicular to each other are provided. The optical fibers are attached to slide terminals which can move along a corresponding one of the guide rails. Thus, the slide terminals are moved by a switching mechanism so as to make a connection between desired optical fibers. Such an optical fiber connection switching apparatus is disclosed in Unexamined Japanese Patent Publication No. Hei-3-287212.

Optical fibers are connected with each other by placing an end surface of one optical fiber so that it is opposite to an end surface of another optical fiber. A driving mechanism is then used to move, position and hold the optical fiber. A conventional optical fiber driving mechanism is one that holds an optical fiber by use of a pair of driving rollers, and rotates the driving rollers so as to move the optical fiber which is being held. This type of driving mechanism has been used as a means for placing optical fibers so that they are opposite to each other.

Each of the aforementioned optical switches can adequately be applied in a limited number of special conditions. However, various problems occur when a large number of optical fibers are used in optical fiber network. For example, if switching is required when there are a large number of optical fibers, it is necessary to miniaturize and integrate the optical while maintaining the ease of operation thereof. However, as mentioned above, it is difficult to make relatively small optical switches.

If a switch having the function of an N × M type optical switch is intended to be realized through the use of conventional 1 × N type optical switches, at least (M) 1 × N type optical switches would be required. For example, if a switch having a function of 8 × 12 were required, (12) 1 × 8 type optical switches would have to be used. Thus, It is difficult to miniaturize the apparatus due to the space which is occupied by each of the 1 × N type optical switches. On the other hand, in a true N × M type optical switch, it is possible to miniaturize the apparatus in comparison with a switch having the same function but being comprised of 1 × N type optical switches. However, a switching mechanism would be required in the true N × M type optical switch for moving respective slide terminals on the N-side and the M-sides along their corresponding guide rails.

If it is necessary to switch a plurality of slide terminals at the same time, a plurality of such switching mechanisms would be needed. The number of switching mechanisms required would be equal to the total number of optical fibers (i.e. N+M). Thus, miniaturize the N × M type optical switch is difficult. Moreover, highly rigid guide rails are needed for positioning the slide terminals with a high degree of accuracy. Therefore, it is impossible to miniaturize the slide terminals or the guide rails. Accordingly, a large switching mechanism causes design problems.

On the other hand, in a conventional optical fiber driving mechanism, the pair of driving rollers which are holding an optical fiber are merely rotated so as to move the optical fiber. Therefore, the structure of the driving mechanism can readily be achieved. However, there are many problems with the miniaturization of this type of

optical switch which are similar to the problems encountered with the miniaturization of the aforementioned switching mechanism used in N × M type optical switches. For example, when driving mechanisms are used in an N × M type optical switches, a driving mechanism must be provided for each optical fiber on the N-side and the M-side, thereby making it difficult to miniaturize the optical switch. Moreover, when a driving mechanism is used, it becomes necessary to position a slide terminal with a high degree of accuracy. Therefore, it is necessary to provide a device, which is separate from the driving mechanism, so as to ensure a high degree of accuracy in the positioning of the slide terminal. This added device cause the cost of the optical switch to increase.

From a prior art publication IEICE Transactions on Communications, Vol. E75-B No. 12, Dec. 1972, pages 1373-1375 entitled "Cassette-type Non-blocking 100 x 100 Optomechanical Matrix Switch" by T. Katagiri et al a cassette-type non-blocking 100 x 100 optomechanic matrix switch is known comprising two ferrule terminated fibre groups which are held in cassettes. The two cassette groups are made by stacking cassettes. The two groups are positioned with their faces at right angles to the longitudinal direction of the cassettes with a space between them. Slider moving mechanisms are built into the facing sides of each cassette. Each slider is equipped with a ferrule which can be independently and arbitrarily positioned along the facing side. As a result, two ferrule terminated fibre groups can be joined in moving their ferrules to face each other.

SUMMARY OF THE INVENTION

The present invention solves the foregoing problems. It is an object of the present invention to provide a relatively small optical fiber switching apparatus which has a relatively simple structure at a reduced cost and maintains the ease of switching operations.

The foregoing object is solved according to the present invention, by an optical fiber switching apparatus according to claim 1. A guide frame, which is supported by the apparatus body, has a guide groove. A moveable moving member is disposed on the guide groove. A slide terminal for supporting an end face of an optical fiber is also provided. The apparatus includes support means for connecting the slide terminal to the moving member. This connection enables the slide terminal to approach or move away from the moving member and also causes the slide terminal to enter a predetermined locked position on the guide frame. The apparatus includes a driving wire which has two end portions. The end portions are disposed through the moving member and are coupled to the slide terminal. By this arrangement of the driving wire, a loop is formed. The apparatus can then move the slide terminal by causing tension on the driving wire which in turn cause the end portions to move the slide terminal towards the moving member. When the slide terminal is moved towards the moving member, the moving member and the slide terminal are free to move along the guide groove by the longitudinal movement of the driving wire.

According to a preferred embodiment of the present invention, an optical fiber switching apparatus has optical coupling members disposed so as to be substantially parallel to each other and being disposed opposite the guide frame.

The object is further solved according to the present invention, by an optical fiber switching apparatus according to claim 3 which has first and second guide frames. The first guide frames are stacked so that they are all substantially parallel to each other. The second guide frames are stacked so that they are all substantially parallel to each other and substantially perpendicular to each of the first guide frames. Each guide frame has a guide groove and an engagement groove. Moving members are also provided. Each moving member is disposed on a corresponding one of the guide grooves. The apparatus also includes slide terminals, each for supporting an end face of an optical fiber. Means are also provided for connecting each of the slide terminals to a corresponding one of the moving members, for enabling each slide terminal to approach or move away from the corresponding moving member, and for causing each slide terminal to enter a corresponding predetermined locked position along a corresponding one of the engagement grooves. The apparatus also includes first driving wires, each having two end portion. The end portions of each driving wire are disposed through a corresponding one of the moving members and are coupled to a corresponding one of the slide terminals, thereby forming a loop in each of the driving wires. Finally, means are provided for moving each slide terminal by tension of a corresponding one of the driving wires so as to cause the end portions of the corresponding driving wire to move the corresponding one of the slide terminal towards or away from the corresponding one of the first moving member, and for moving each moving member along the corresponding guide groove by the longitudinal movement of the corresponding one of the driving wires, thereby causing a corresponding one of the slide terminals to move toward the corresponding predetermined locked position along the corresponding engagement groove.

Finally, according to a preferred embodiment of the present invention defined in claim 3 the optical fiber switching apparatus has the additional features of claim 4.

By the foregoing apparatus, a selected one of the first optical fiber can be inserted into a selected one of the capirallies when the slide terminal which corresponds to the selected first optical fiber enters the locked position and the slide terminal which corresponds to the selected capirally enters the locked position. Therefore, optical coupling between the selected first optical fiber and the second optical fiber which cor-

responds to the selected capirally can occur.

The apparatus described above may include capirallies which have taper-shaped insertion opening. Each taper-shaped insertion opening has an internal diameter which decreases and an inside face which is smooth. The first end face may be rounded. Rounding of the end face may be done by grinding or electrical discharging. The first optical fiber may be coated by a carbon layer. A silicone thin film may be formed on each of the second end faces.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic perspective view of an optical fiber switching apparatus according to the present invention;

Fig. 2 is a schematic perspective view of a moving member and a slide terminal of an optical fiber switching apparatus;

Fig. 3 is a plan view of an optical fiber switching apparatus;

Fig. 4 is a plan view showing the function of an optical fiber switching apparatus;

Fig. 5 is a schematic perspective view of an optical fiber switching apparatus as formed into a unit;

Fig. 6 is a schematic perspective view showing the function of an optical fiber switching apparatus;

Fig. 7 is a schematic perspective view showing a optical coupling using a capirally;

Fig. 8 is a plan view showing a top end of a capirally and an end face of an optical fiber; and

Fig. 9 is a plan view showing a silicone thin film formed on an end face of an optical fiber which is fixed in a capirally.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Specific embodiments of the present invention will now be described in detail with reference to the Figures.

An optical fiber switching apparatus, according to the present invention, can make a connection (i.e. optical coupling) between a plurality of optical fibers. The optical fiber switching apparatus can also switch the connection between the optically coupled optical fibers. Fig. 5 depicts a plurality of first guide frames 11 formed in the shape of thin plates. First guide frames 11 are horizontally disposed and stacked so as to be parallel with each other on their corresponding back sides (i.e. the left side in Fig. 5) in a housing 51. A plurality of second guide frames 41 are also formed in the shape of thin plates. Second guide frames 41 are stacked vertically and are disposed on a front side of first guide frames 11 (i.e. the right side in Fig. 5) so as to cross first guide frames 11 in housing 51.

In each first guide frame 11, as shown in Figs. 1 and 3, a pair of first guide grooves 12 are formed along the front of first guide frame 11. First guide grooves 12 are formed so as to be parallel with each other. A first moving member 14 is movably attached to first guide grooves 12 by the use of first guide pins 13. An engagement groove 15 is formed on first guide frame 11. Engagement groove 15 is also formed parallel to first guide grooves 12 and has a comb portion 16.

A first slide terminal 17 is coupled to first moving member 14 by use of a pair of springs 18 which act as support members. First moving member 14 is movably attached in engagement groove 15 through second guide pins 19. Moving member 14 is arranged so as to be locked to first guide frame 11 when second guide pins 19 are fitted into comb portion 16 by the use of springs 18.

As seen in Fig. 2, a passage groove 21 is formed in a center portion of first moving member 14 and is perpendicular to the direction of movement of first moving member 14. Passage groove 21 accepts a first optical fiber 20 which acts as an optically coupled member for switching. A pair of arc-like passage grooves 23 are formed on opposite sides of passage groove 21. A first driving wire 22 is inserted in each arc-like passage grooves 23. A holding groove 24, which is able to communicate with passage groove 21, is formed in first slide terminal 17. A ferrule 25 is fixed to holding groove 24 and holds an end portion of first optical fiber 20.

As shown in Figs. 1 and 3, a parallel pair of second guide grooves 26 are formed along the back of first guide frame 11. A first driving member 28 is movably attached to second guide grooves 26 by third guide pins 27. First driving member 28 has a passage hole 29 which is formed in the direction of movement of first driving member 28. Thus passage hole 29 is formed in the longitudinal direction of second guide grooves 26 so that first driving wire 22 can be inserted through passage hole 29. A through hole 30 is formed perpendicular to passage hole 29 so that a driving piece 65 can be inserted-into or separated-from through hole 30.

Support pins 31 are disposed in each of the corner portions of first guide frame 11. First driving wire 22 is looped around the outside of each support pin 31 and is passed through passage hole 29. The ends of first driving wire 22 are coupled to first slide terminal 17 through their respective arc-like passage groove 23. First driving wire 22 is curved through first driving member 28 so that first driving wire 22 is slightly loose when first slide terminal 17 is separated from first moving member 14 and second guide pins 19 are fitted into comb portion 16.

As shown in Fig. 5, the difference between second guide frames 41 and first guide frames 11 is merely their respective positions. Thus, second guide frames 41 have components mounted thereon which are similar to the components mounted on first guide frames 11. For example, second guide frames 41 contain a second moving member 42, a second slide terminal 43, a second driving member 44, a second driving wire 45 and a second optical fiber 46 which is to be connected and

switched to first optical fiber 20. Therefore, a detailed description of these components is not included herein. However, the corresponding descriptions of the components of first guide frames 11 should be consulted if there is any question as to how second guide frames 41 are designed.

In the preferred embodiment, approximately 100 first guide frames 11 and second guide frames 41, each of which is approximately 0.5 mm thick, are stacked and separated by spacers 32 as shown in Fig. 1. Each spacer 32 is approximately 0.5 mm thick. First and second moving members 14 and 42, first and second slide terminals 17 and 43, and first and second driving members 28 and 44 are also approximately 0.5 mm thick. Accordingly, each unit (i.e. a guide frame 11 or 41 and all of the parts disposed thereon, including a spacer 32) is approximately 1.0 mm thick.

As shown in Fig. 5, driving mechanisms for first and second driving members 28 and 44 are provided for enabling the connection of first and second optical fibers 20 and 46. Driving members 28 and 44 are also provided for allowing the connection between first and second optical fibers 20 and 46 to be switched. Two upper and lower horizontal drivers 53 are provided (the upper left and lower right horizontal driver 53 are not shown in Fig. 5). Each upper horizontal drivers 53 is coupled through a vertical coupling shaft 52 to a corresponding lower horizontal driver 53, thereby forming two pairs of horizontal drivers 53. Each horizontal driver 53 is movably supported by a corresponding horizontal guide 54 which is attached to housing 51. Each pair of horizontal drivers 53 is engaged with a corresponding horizontal screw shaft 55. Each horizontal screw shaft 55 is coupled to a corresponding horizontal driving motor 56 through a corresponding horizontal coupling belt 57, thereby allowing each horizontal driver 53 to be driven.

Two left and right vertical drivers 59 are also provided. Each left vertical driver 59 is coupled to a corresponding right vertical driver 59 through a horizontal coupling shaft 58, thereby creating two pairs of vertical drivers 59. Each vertical driver 59 is movably supported by a corresponding vertical guide 60 which is attached to housing 51. Each pair of vertical drivers 59 is engaged with a corresponding vertical screw shaft 61. Each vertical screw shaft 61 is coupled with a corresponding vertical driving motor 62 through a corresponding vertical coupling belt 63, thereby allowing each vertical driver 59 to be driven.

A first driver 64 is disposed at the back side of first guide frame 11, and is penetrated by one of the vertical coupling shafts 52 and one of the horizontal coupling shafts 58. In this configuration, first driver 64 can be moved up and down, and right and left by the driving of the respective horizontal driving motor 56 and the respective vertical driving motor 62. A first driving shaft 66, in which an arc-like horizontal driving piece 65 is formed on the top end portion thereof, is movably mounted on the first driver 64. First driving shaft 66 can be moved by a shaft driving motor (not shown). Arc-like horizontal driving piece 65 fits into through hole 30 of first driving member 28 so that arc-like horizontal driving piece 65 can make first driving wire 22, which was originally loose, as shown in Fig. 3, tense, as shown in Fig 4.

Although a driving mechanism for driving second driving member 44 is provided in housing 51, it has substantially the same structure, except that an arc-like vertical driving piece 69 of second driving shaft 68 is mounted in a vertical direction instead of the horizontal direction in which arc-like horizontal driving piece 65 is mounted in. Therefore, a detailed description of these components is not included herein. However, the corresponding descriptions of the components of first driver 64 should be consulted if there is any question as to how second driver 67 is designed or operates.

The operation of making a connection and changeover the connection between optical fibers by the optical fiber switching apparatus of this embodiment will now be described. As shown in Fig. 5, first driver 64 is moved up and down, and right and left by the driving of the respective horizontal driving motor 56 and the respective vertical driving motor 62. Thus, first driver 64 can be located in a predetermined position. For example, arc-like horizontal driving piece 65 of first driver 64 can be moved so as to be opposite to first driving member 28 of a selected one of the first guide frames 11, as shown in Fig. 3. First driving shaft 66 can then be moved forward so as to fit arc-like horizontal driving piece 65 into through hole 30 of first driving member 28, as shown in Fig. 4. First driving wire 22, which was loose in first driving member 28, is then made tense. The end portion of first driving wire 22 is then pulled so that first slide terminal 17 moves against the force of springs 18. As a result, first guide pins 13 are drawn out of comb portion 16 so as to release the fitting, thereby allowing first slide terminal 17 and first moving member 14 to contact tightly with each other.

In other words, when the respective horizontal driving motor 56 is driven so as to move first driver 64 into position behind a selected first driving member 28 and arc-like horizontal driving piece 65 inserted into the corresponding through hole 30, first driving wire 22 is longitudinally. First slide terminal 17 and first moving member 14 then move along the pair of first guide grooves 12. Horizontal driving motor 56 is stopped when first slide terminal 17 reaches a position where the end portion of first optical fiber 20 is opposite to the end portion of second optical fiber 46, thereby allowing the switching of the connection between first optical fibers 20 and second optical fiber 46.

Once the connection is switched, first driving shaft 66 is moved backward, thereby drawing arc-like horizontal driving piece 65 out of through hole 30, as shown in Fig. 3. The tension of first driving wire 22 is loosened as a result of the removal of arc-like horizontal driving piece 65 from through hole 30. The loosening of first driving wire 22 in turn causes first slide terminal 17 to

be moved by the urging force of springs 18. First guide pins 13 are then fitted into comb portion 16 of the engagement groove 15, thereby causing first slide terminal 17 to be locked in place. Thus, the positioning of first optical fiber 20 is complete.

Second driver 67 is moved in a similar manner so as to position arc-like vertical driving piece 69 opposite to a selected second driving member 44. Arc-like vertical driving piece 69 is then fitted into a through hole (not shown) of the selected second driving member 44 so as to create tension or loosen second driving wire 45. Furthermore, the engagement of second slide terminal 43 causes it to be released so that second slide terminal 43 is brought into tight contact with second moving member 42. Second driver 67 is then moved vertically so as to cause second driving member 44 to be moved through the use of arc-like vertical driving piece 69. Second driving wire 45 is then moved longitudinally. Accordingly, second slide terminal 43 moves along the guide grooves of the corresponding second guide frame along with second moving member 42. Second slide terminal 43 is stopped when it reaches a position where the end portion of second optical fiber 46 is opposite to the end portion of first optical fiber 20.

Once in position, arc-like vertical driving piece 69 is moved so that it is drawn out of the through hole which corresponds to the second driving member 44. As a result, the tension on second driving wire 45 is released. Accordingly, second slide terminal 43 is locked in the appropriate engagement grooves. The end portions of first optical fiber 20 and second optical fiber 46 are therefore positioned opposite to each other with a predetermined distance between them so as to allow first and second optical fibers 20 and 46 to be optically coupled with each other. Thus, the process of switching of the optical fibers is complete.

The aforementioned operations of connecting and switching connections between optical fibers are performed automatically by a control means. The procedures of moving first and second optical fibers 20 and 46 are not intended to be limited to the procedures described in the preferred embodiment.

Although, in the preferred embodiment, the connecting and switching of connections between optical fiber is performed by inserting first optical fiber 20 into ferrule 25, which is formed on holding groove 24, as shown in Fig. 2, optical coupling by the use of a capirally will now be described.

Fig. 6 is a schematic view showing optical coupling by the use of a capirally 72. First optical fiber 20 is inserted into capirally 72. Capirally 72 has a taper-shaped insertion opening 71. The internal diameter of taper-shaped insertion opening 71 decreases from the top end to the internal end thereof. Second optical fiber 46 is inserted into taper-shaped insertion opening 71 so that the end portion of second optical fiber 46 opposes the end portion of first optical fiber 20. Thus, optical coupling can occur. It is noted that taper-shaped insertion opening 71 has a face which is flat and smooth so that the end of second optical fiber 46 is not chipped. Furthermore, capirally 72 is of low-cost as compared to other optical connector, thereby reducing the cost of the switching apparatus.

Fig. 7 is a schematic view showing the use of capirally 72 in an optical fiber switching apparatus according to the present invention. The elements depicted in Fig. 7 are substantially the same as the elements depicted in Figs. 1-5. Thus, the same numerals are used to designated the elements which are the same. Moreover, so as not to be repetitive, the description of these elements is omitted. However, the positions of first guide frame 11 and second guide frame 41 have been reverse for the explanation which follows.

Referring to Fig. 6, the external diameter (ED) of the capirally 72 is approximately 1 mm, the internal diameter (ID) thereof is approximately 0.126 mm and the taper diameter of the end portion is approximately 0.72 mm. The terminals can slide right and left or up and down and can push forward second optical fiber 46 or capirally 72. Capirally 72 is fixed to first slide terminal 17, and first optical fiber 20 is fixed in capirally 72. Second optical fiber 46 is fixed to second slide terminal 43.

Second slide terminal 43 is moved to a position so that it opposes first slide terminal 17 by a moving unit as a robot hand or the like. Second slide terminal 43 is also pushed forward so that second optical fiber 46 is inserted into capirally 72, thereby causing first and second optical fibers 20 and 46 to become optically coupled. Even if an axis aberration of about ± 0.3 mm is generated between second optical fiber 46 and capirally 72, the elastic deformation of second optical fiber 46 and taper-shaped insertion opening 71 of capirally 72 enables optical coupling to be accomplished.

As described above, second optical fiber 46 is disposed in second slide terminal 43. Capirally 72 is fixed to first optical fiber 20 and both are disposed in first slide terminal 17. Second slide terminal 43 is pushed forward so as to insert second optical fiber 46 into capirally 72. Once inserted into capirally 72, first and second optical fibers 20 and 46 oppose each other so as to allow optical coupling thereof.

Since the external diameter (ED) of capirally 72 can be extremely small and since the internal diameter (ID) thereof can be substantially same as the external diameter of an optical fiber inserted therein, first slide terminal 17 can be extremely small thereby allowing the miniaturization of the entire switching apparatus.

The taper-shaped insertion opening 71 is formed on an insertion end portion of capirally 72 so that second optical fiber 46 is deformed elastically so as to allow second optical fiber 46 to be easily inserted into capirally 72 from the insertion end thereof even if second optical fiber 46 is displaced from the position of capirally 72. In other words, the position of capirally 72 causes second optical fiber 46 to be deflected. Accordingly, is not required that the positions of first and second slide termi-

nals 17 and 43 be precise when stopped and locked in position.

Fig. 8 is a plan view showing the end of capirally 72 and the end face 46a of second optical fiber 46. As shown in Fig. 8, end face 46a of is rounded. Rounding of end face 46a can be performed by grinding or electrically discharging. Rounding of end face 46a helps to ensure that second optical fiber 46 is not chipped when it comes in contact with taper-shaped insertion hole 71. Furthermore, second optical fiber 46 is coated with carbon layer so as to increase the durability of the second optical fiber 46. Durability is important since second optical fiber 46 undergoes elastic deformation when displaced by taper-shaped insertion opening 71.

Fig. 9 shows a silicone thin film 73 formed on the end face of first optical fiber 20. Silicone thin film 73 is formed on the end face of first optical fiber 20 so as to prevent the reflection of the light which is propagated along first optical fiber 20.

As has been described in detail above, in the optical fiber switching apparatus according to the present invention, a moving member is provided which moves along a guide groove of a guide frame. A slide terminal for supporting an end portion of an optical fiber is coupled with the moving member through a support member. In this configuration, the slide terminal can approach or move away from the moving member. Furthermore, the slide terminal can be locked to the guide frame. The end portions of a driving wire are coupled with the slide terminal through the moving member so that the driving wire is formed into a loop. Accordingly, the slide terminal is moved by a driving means through the traction of the end portions of the driving wire. The moving member is also moved at the same time by the longitudinal movement of the driving wire. Thus, moving, positioning and holding of the optical fibers, and optical coupling of the optical fibers can be performed by only the movement of the driving wire. Not only it is possible to miniaturize the switching apparatus, it is also possible to simplify its structure, reduce its cost, and facilitate the switching operation of the switching apparatus.

For improved optical coupling, the above switching apparatus uses a capirally which also solves the problem of miniaturization with respect to the size of the optical connector. In addition, since typical optical connector permits only small displacements of optical fibers, high precision is required to couple the optical fibers when such a connector is used. However, the taper-shaped insertion opening of the capirally allows for easy insertion of the optical fiber and even accomplishes stable optical coupling when there is a displacement in the position between the optical fiber to be inserted and the capirally.

The end face of the optical fiber is rounded and the taper-shaped insertion opening of the capirally is smooth so as to prevent chipping of the optical fiber when it is being inserted into the capirally. The optical fiber being inserted can also be coated with a carbon layer so as to increase the durability of the optical fiber since it may undergo elastic deformation. Furthermore, measures may be taken so as to deal with the reflection of the light. A conventional method uses index matching material. However, the material can not be filled in the capirally sufficiently because of the extremely thin internal diameter of the capirally. This usually causes bubbles to be generated in the material when the optical fiber is inserted or extracted because of change of the internal pressure of the capirally. However, in the present invention, a silicone thin film is formed on the end face of the optical fiber which is fixed into the capirally so as to solve the problems just described, thereby preventing the reflection of the light.

Claims

1. An optical fibre switching apparatus comprising:

an apparatus body (51),

a guide frame (11), which is supported by the apparatus body, having a guide groove (12);

a moving member (14) disposed on the guide groove (12) so as to be movable along the guide groove;

a slide terminal (17) supporting an end face of an optical fibre (20);

locking means (16) on the guide frame for locking the slide terminal (17) in one of a plurality of positions;

support means (18) connecting the slide terminal resiliently to the moving member so as to enable the slide terminal (17) to be moved towards the moving member thereby causing the slide terminal to be released from the locking means, and so as to enable the slide terminal (17) to be moved away from the moving member thereby causing the slide terminal to become locked in one of said positions;

a driving wire (22) having a first end portion and a second end portion, the first end portion and the second end portion being disposed through the moving member (14) and being fixed to the slide terminal (17), thereby forming a loop in the driving wire;

driving means for causing the slide terminal (17) to be released from the locking means (16) by tensioning the driving wire and thereby causing the first end portions and the second end

portion of the wire to pull the slide terminal against the force of the resilient support means (18) towards the moving member (14), and for moving the moving member along the guide groove by a longitudinal movement of the driving wire when the slide terminal is released.

2. An optical fibre switching apparatus according to claim 1, wherein the apparatus comprises:
a plurality of optical coupling members, the optical coupling members being substantially parallel to each other and being dispersed opposite the guide frame for optical coupling to the fibre on the slide terminal (17).

3. An optical fibre switching apparatus comprising:

a plurality of first guide frames (11) which are stacked one above the other so that all of the first guide frames are substantially parallel to each other, each first guide frame having a first guide groove (12);

a plurality of second guide frames (41), which are stacked one above the other so that all of the second guide frames are substantially parallel to each other each second guide frame (41) having a second guide groove; the stacks being disposed such that the frame planes of the first stack are substantially perpendicular to those of the second stack,

a plurality of first moving members (14) each disposed on a corresponding one of the first guide grooves (12) so as to be movable along the corresponding first guide groove;

a plurality of second moving members, each disposed on a corresponding one of the second guide grooves so as to be movable along the corresponding second guide groove;

a plurality of first slide terminals (17) each supporting first end face of a corresponding first optical fibre (20);

a plurality of second slide terminals, each supporting a second end face of a corresponding second optical fibre;

a plurality of first engagement grooves (16) on each of the first and second guide frames (11, 41) for locking the associated slide terminal in one of a plurality of positions;

support means (18) connecting each of the first slide terminals resiliently to a corresponding one of the first moving members, and connecting each of the second slide terminals to a corresponding one of the second moving members is as to enable each first slide terminal to be moved towards the corresponding first moving member thereby causing each first slide terminal to be released from on the engagement grooves, and so as to enable each first slide terminal to be moved away from the corresponding first moving member thereby causing each first slide terminal to become locked in one of said positions on a corresponding one of the first engagement grooves; and so as to enable each second slide terminal to be moved towards the corresponding second moving member thereby causing each second slide terminal to be released from the engagement grooves, and so as to enable each second slide terminal to be moved away from the corresponding second moving member thereby causing each second slide terminal to become locked in one of said positions on a corresponding one of the second engagement grooves;

a plurality of first driving wires (22), each having first end portions and a second end portion, the first end portion and the second end portion of each first driving wire being disposed through a corresponding one of the first moving members (14) and being fixed to a corresponding one of the first slide terminals (17), thereby forming a loop in each of the first driving wires;

a plurality of second driving wires, each having a third end portion and a fourth end portion, the third end portion and the fourth end portion of each second driving wire being disposed through a corresponding one of the second moving members and being fixed to a corresponding one of the second slide terminals, thereby forming a loop in each of the second driving wires;

driving means for causing a selected one of the first slide terminals (17) to be released from the engagement grooves by tensioning the first driving wire and thereby causing the first end portion and the second end portion of the wire to pull the selected first slide terminal against the force of the resilient support means (18) towards the corresponding first moving member (14) for moving the corresponding first moving member along the corresponding first guide groove by a longitudinal movement of the first driving wire when the selected first slide terminal is released; and for causing a selected one of the second slide terminals to be released from the engagement grooves by tensioning the second driving wire and thereby causing the

third end portion and the fourth end portion of the wore to pull the selected second slide terminal against the force of the resilient support means towards the corresponding second moving member, and for moving the corresponding second moving member along the corresponding second guide groove by a longitudinal movement of the second driving wire when the selected second slide terminal is released.

4. An optical fibre switching apparatus, according to claim 3, wherein a capirally (/2) is disposed in each of the second slide terminals, each capirally (72) having the end face of a corresponding second optical fibre fixed therein; and wherein an end portion of a selected one of the first optical fibres (20) is inserted into a selected one of the capirallies when the slide terminal supporting the selected first optical fibre enters an engagement grooves and when the slide terminal supporting the selected capirally enters, at a position opposite to the first slide terminal, an engagement groove whereby the selected first optical fibre is optically coupled to the second optical fibre fixed within the selected capirally.

5. An optical fibre switching apparatus according to claim 4, wherein each capirally (72) has a taper-shaped insertion opening, each taper-shaped insertion opening having an internal diameter which decreases and an inner surface which is smooth, and wherein the end face of the first optical fibres are rounded.

6. An optical fibre switching apparatus according to claim 4, wherein the end portion of each second optical fibre is coated with a carbon layer.

7. An optical fibre switching apparatus according to claim 4, wherein a silicone thin film is formed on each of the end faces of the first fibres.

8. An optical fibre switching apparatus according to claim 5, wherein the end face of each first fibre is rounded by grinding or electrical discharging.

9. An optical fibre switching apparatus according to claim 6, wherein a silicone thin film is formed on each of the end faces of the first fibres.

Patentansprüche

1. Schaltvorrichtung für optische Fasern mit:

einem Gerätekörper (51),

einer Führungshalterung (11), die durch den Gerätekörper gehaltert ist und eine Führungsnut (12) aufweist;

einem beweglichen Element (14), das auf der Führungsnut (12) so angeordnet ist, daß es entlang der Führungsnut verschiebbar ist;

einer Verschiebestation (17), die eine Endfläche einer optischen Faser (20) haltert;

einem Arretierungsmittel (16) auf der Führungshalterung zum Arretieren der Verschiebestation (17) in einer Position von einer Vielzahl von Positionen;

einem Halterungsmittel (18), das die Veschiebestation elastisch mit dem beweglichen Element verbindet, um somit zu ermöglichen, daß die Verschiebestation (17) gegen das bewegliche Element bewegbar ist, wodurch ein Lösen der Verschiebestation von dem Arretierungsmittel hervorgerufen wird, und um somit zu ermöglichen, daß die Verschiebestation (17) von dem beweglichen Element weg bewegt wird, wodurch bewirkt wird, daß die Verschiebestation in einer der Positionen arretiert wird;

einem Antriebsseil (22) mit einem ersten Endteil und einem zweiten Endteil, wobei der erste Endteil und der zweite Endteil durch das bewegliche Element (14) durchgeführt sind und an der Verschiebestation (12) fixiert sind, wodurch in dem Antriebsseil eine Schlaufe gebildet wird;

einem Antriebsmittel, um zu bewirken, daß die Verschiebestation (17) von den Arretierungsmitteln (16) gelöst wird durch Spannen des Antriebsseils, wodurch bewirkt wird, daß der erste Endteil und der zweite Endteil des Seils die Verschiebestation gegen die Kraft des elastischen Halterungsmittels (18) gegen das bewegliche Element (14) ziehen, und zum Bewegen des bewegbaren Elements entlang der Führungsnut durch eine Bewegung des Antriebsseils in Längsrichtung, wenn die Verschiebestation freigegeben ist.

2. Schaltvorrichtung für optische Fasern gemäß Anspruch 1, wobei die Vorrichtung umfaßt:
eine Vielzahl von optischen Kopplungselementen, wobei die optischen Kopplungselemente im wesentlichen parallel zueinander und gegenüber zu der Führungshalterung verteilt sind zur optischen Kopplung an die Fasern der Verschiebestation (17).

3. Schaltvorrichtung für optische Fasern mit:

einer Vielzahl von ersten Führungshalterungen (11), die eine über der anderen so aufgestapelt sind, daß alle ersten Führungshalterungen im wesentlichen parallel zueinander sind, wobei jede erste Führungshalterung eine erste Führungsnut (12) aufweist;

einer Vielzahl von zweiten Führungshalterungen (41), die so eine über der anderen aufgestapelt sind, daß alle zweiten Führungshalterungen im wesentlichen parallel zueinander sind, wobei jede zweite Führungshalterung (41) eine zweite Führungsnut aufweist; wobei die Stapel so angeordnet sind, daß die Ebenen der Halterungen des ersten Stapels im wesentlichen senkrecht zu denen des zweiten Stapels sind;

einer Vielzahl von ersten beweglichen Elementen (14), die jeweils auf einer entsprechenden ersten Führungsnut (12) so angeordnet sind, daß sie entlang der entsprechenden ersten Führungsnut verschiebbar sind;

einer Vielzahl von zweiten beweglichen Elementen, die jeweils auf einer entsprechenden Nut der zweiten Führungsnuten so angeordnet sind, daß sie entlang der entsprechenden zweiten Führungsnut bewegbar sind;

einer Vielzahl von ersten Verschiebestationen (17), die jeweils eine erste Endfläche einer entsprechenden ersten optischen Faser (20) halten;

einer Vielzahl von zweiten Verschiebestationen, die jeweils eine zweite Endfläche einer entsprechenden zweiten optischen Faser halten;

einer Vielzahl von Eingriffsnuten (16) auf jeder der ersten und zweiten Führungshalterungen (11, 41) zum Arretieren der zugeordneten Verschiebestationen in einer Position von einer Vielzahl von Positionen;

Halterungsmitteln (18), die jeweils die ersten Verschiebestationen elastisch mit einem entsprechenden Element der ersten beweglichen Elemente verbinden und die jede der zweiten Verschiebestationen mit einem entsprechenden Element der zweiten beweglichen Elemente verbinden, um somit zu ermöglichen, daß jede erste Verschiebestation gegen das entsprechende erste bewegliche Element bewegbar ist, um dadurch hervorzurufen, daß jede erste Verschiebestation aus den Eingriffsnuten lösbar ist, und um zu ermöglichen, daß jede erste Verschiebestation von dem entsprechenden beweglichen Element weg bewegbar ist, um dadurch zu bewirken, daß jede erste Verschiebestation in einer der Positionen einer entsprechenden Nut der ersten Eingriffsnuten arretiert wird; und um somit zu ermöglichen, daß jede zweite Verschiebestation gegen das entsprechende Element der zweiten beweglichen Elemente bewegbar ist, um dadurch zu bewirken, daß jede zweite Verschiebestation aus den Eingriffsnuten freigebbar ist, und um somit zu ermöglichen, daß jede zweite Verschiebestation von dem entsprechenden Element der zweiten beweglichen Elemente weg bewegbar ist, um dadurch zu bewirken, daß jede zweite Verschiebestation in einer der Positionen einer entsprechenden Nut der zweiten Eingriffsnuten arretiert wird;

einer Vielzahl von ersten Antriebsseilen (22), die jeweils erste Endteile und zweite Endteile aufweisen, wobei der erste Endteil und der zweite Endteil jedes ersten Antriebsseils durch ein entsprechendes Element der ersten beweglichen Elemente (14) durchgeführt und an einer entsprechenden Station der ersten Verschiebestationen (17) fixiert sind, wodurch eine Schlaufe in jedem der ersten Antriebsseile gebildet wird;

einer Vielzahl von zweiten Antriebsseilen, die jeweils einen dritten Endteil und einen vierten Endteil aufweisen, wobei der dritte Endteil und der vierte Endteil jedes zweiten Antriebsseils durch ein entsprechendes Element der zweiten beweglichen Elemente durchgeführt und an einer entsprechenden Station der zweiten Verschiebestationen fixiert sind, wodurch eine Schlaufe in jedem der zweiten Antriebsseile gebildet wird;

Antriebsmitteln, um zu bewirken, daß eine ausgewählte erste Verschiebestation (17) aus den Eingriffsnuten gelöst wird durch Spannen des ersten Antriebsseils, um dadurch zu bewirken, daß der erste Endteil und der zweite Endteil des Seils die ausgewählte Verschiebestation gegen die Kraft des elastischen Halterungsmittels (18) zum entsprechenden ersten beweglichen Element (14) ziehen, um das entsprechende erste bewegliche Element entlang der entsprechenden ersten Führungsnut durch eine Bewegung des ersten Antriebsseils in einer Längsrichtung zu bewegen, wenn die ausgewählte erste Verschiebestation freigegeben ist; und um zu bewirken, daß eine ausgewählte zweite Verschiebestation aus den Eingriffsnuten gelöst wird durch Spannen des zweiten Antriebs-

seils, und um dadurch zu bewirken, daß der dritte Endteil und der vierte Endteil des Seils die ausgewählte zweite Verschiebestation gegen die Kraft des elastischen Halterungsmittels zum entsprechenden zweiten beweglichen Element ziehen, und um das entsprechende zweite bewegliche Element entlang der entsprechenden zweiten Führungsnut durch eine Bewegung in Längsrichtung des zweiten Antriebsseils zu bewegen, wenn die ausgewählte zweite Verschiebestation freigegeben ist.

4. Schaltvorrichtung für optische Fasern gemäß Anspruch 3, wobei eine Kapillare (72) in jeder der zweiten Verschiebestationen angeordnet ist, wobei in jeder Kapillare (72) die Endfläche einer entsprechenden zweiten optischen Faser fixiert ist; und wobei ein Endteil einer ausgewählten Faser der ersten optischen Fasern (20) in eine ausgewählte Kapillare eingefügt wird, wenn die Verschiebestation, die die ausgewählte erste optische Faser haltert, in eine Eingriffsnut eintritt, und wenn die Verschiebestation, die die ausgewählte Kapillare haltert, an einer Position gegenüber zu der ersten Verschiebestation in eine Eingriffsnut eintritt, wobei die ausgewählte erste optische Faser mit der zweiten optischen Faser, die in der ausgewählten Kapillare fixiert ist, optisch gekoppelt wird.

5. Schaltvorrichtung für optische Fasern gemäß Anspruch 4, wobei jede Kapillare (72) eine konisch geformte Einfügungsöffnung aufweist, wobei jede konisch geformte Einfügungsöffnung einen sich verringernden inneren Durchmesser und eine glatte innere Oberfläche aufweist, und wobei die Endfläche der ersten optischen Fasern abgerundet ist.

6. Schaltvorrichtung für optische Fasern gemäß Anspruch 4, wobei der Endteil jeder zweiten optischen Fasern mit einer Kohlenstoffschicht beschichtet ist.

7. Schaltvorrichtung für optische Fasern gemäß Anspruch 4, wobei ein dünner Silikonfilm an jeder der Endflächen der ersten Fasern ausgebildet ist.

8. Schaltvorrichtung für optische Fasern gemäß Anspruch 5, wobei die Endfläche jeder ersten Faser abgerundet ist durch Schleifen oder elektrische Entladung.

9. Schaltvorrichtung für optische Fasern gemäß Anspruch 6, wobei der Silikonfilm auf jeder der Endflächen der ersten Fasern ausgebildet ist.

Revendications

1. Appareil de commutation de fibres optiques comprenant :

un corps d'appareil (51) ;
un cadre (11) de guidage, qui est supporté par le corps d'appareil, comportant une rainure (12) de guidage ;
un élément mobile (14) disposé sur la rainure (12) de guidage de façon à être mobile le long de la rainure de guidage ;
un coulisseau (17) de raccordement supportant une face d'extrémité d'une fibre optique (20) ;
un moyen (16) de verrouillage sur le cadre de guidage destiné à verrouiller le coulisseau (17) de raccordement dans l'une de plusieurs positions ;
un moyen (18) formant support reliant de façon élastique le coulisseau de raccordement à l'élément mobile de façon à permettre au coulisseau (17) de raccordement de se déplacer en direction de l'élément mobile en libérant ainsi le coulisseau de raccordement du moyen de verrouillage, et de façon à permettre au coulisseau (17) de raccordement de s'écarter de l'élément mobile en provoquant ainsi le verrouillage du coulisseau de raccordement dans l'une desdites positions ;
un fil (22) d'entrainement ayant une première partie d'extrémité et une seconde partie d'extrémité, la première partie d'extrémité et la seconde partie d'extrémité étant disposées de façon à traverser l'élément mobile (14) et à être fixées au coulisseau (17) de raccordement, en formant ainsi une boucle dans le fil d'entraînement ;
un moyen d'entraînement destiné à libérer le coulisseau (17) de raccordement du moyen (16) de verrouillage, en tendant le fil d'entraînement et en faisant ainsi que la première partie d'extrémité et la seconde partie d'extrémité du fil tirent le coulisseau de raccordement, contre la force du moyen (18) formant support élastique, en direction de l'élément mobile (14), et destiné à déplacer l'élément mobile le long de la rainure de guidage par un déplacement longitudinal du fil d'entraînement lorsque le coulisseau de raccordement est libéré.

2. Appareil de commutation de fibres optiques selon la revendication 1, dans lequel l'appareil comprend :

plusieurs éléments de raccordement optique, les éléments de raccordement optique étant sensiblement parallèles les uns aux autres et étant répartis en face du cadre de guidage pour raccordement optique à la fibre sur le coulisseau (17) de raccordement.

3. Appareil de commutation de fibres optiques

comprenant :

plusieurs premiers cadres (11) de guidage qui sont empilés l'un au-dessus de l'autre de façon que tous les premiers cadres de guidage soient sensiblement parallèles les uns aux autres, chaque premier cadre de guidage comportant une première rainure (12) de guidage ;
plusieurs seconds cadres (41) de guidage qui sont empilés l'un au-dessus de l'autre de façon que tous les seconds cadres de guidage soient sensiblement parallèles les uns aux autres, chaque second cadre (41) de guidage comportant une seconde rainure de guidage ; les empilements étant disposés de façon que les plans de cadre du premier empilement soient sensiblement perpendiculaires à ceux du second empilement ;
plusieurs premiers éléments mobiles (14), chacun disposé sur l'une, correspondante, des premières rainures (12) de guidage de façon à être mobile le long de la première rainure de guidage correspondante ;
plusieurs seconds éléments mobiles, chacun disposé sur l'une, correspondante, des secondes rainures de guidage de façon à être mobile le long de la seconde rainure de guidage correspondante ;
plusieurs premiers coulisseaux (17) de raccordement, chacun supportant une première face d'extrémité d'une première fibre optique (20) correspondante ;
plusieurs seconds coulisseaux de raccordement, chacun supportant une seconde face d'extrémité d'une seconde fibre optique correspondante ;
plusieurs premières rainures (16) de blocage, sur chacun des premiers et seconds cadres (11, 41) de guidage, destinées à verrouiller le coulisseau de raccordement associé dans l'une de plusieurs positions ;
un moyen (18) formant support reliant chacun des premiers coulisseaux de raccordement élastiquement à l'un. correspondant des premiers éléments mobiles, et chacun des seconds coulisseaux de raccordement élastiquement à l'un, correspondant des seconds éléments mobiles, de façon à permettre à chaque premier coulisseau de raccordement de se rapprocher du premier élément mobile correspondant en provoquant ainsi la libération de chaque premier coulisseau de raccordement des rainures de blocage, et de façon à permettre à chaque premier coulisseau de raccordement de s'écarter du premier élément mobile correspondant en provoquant ainsi le verrouillage de chaque premier coulisseau de raccordement dans l'une desdites positions dans l'une, correspondante, des premières rainures de blocage ; et de façon à permettre à chaque second coulisseau de raccordement de se rapprocher du second élément mobile correspondant en provoquant ainsi la libération de chaque second coulisseau de raccordement des rainures de blocage, et de façon à permettre à chaque second coulisseau de raccordement de s'écarter du second élément mobile correspondant en provoquant ainsi le verrouillage de chaque second coulisseau de raccordement dans l'une desdites positions dans l'une, correspondante, des secondes rainures de blocage ;
plusieurs premiers fils (22) d'entraînement, ayant chacun une première partie d'extrémité et une seconde partie d'extrémité, la première partie d'extrémité et la seconde partie d'extrémité de chaque premier fil d'entraînement traversant l'un, correspondant, des premiers éléments mobiles (14) et étant fixées à l'un, correspondant, des premiers coulisseaux (17) de raccordement, en formant ainsi une boucle dans chacun des premiers fils d'entraînement ;
plusieurs seconds fils d'entraînement, ayant chacun une troisième partie d'extrémité et une quatrième partie d'extrémité, la troisième partie d'extrémité et la quatrième partie d'extrémité de chaque second fil d'entraînement traversant l'un, correspondant, des seconds éléments mobiles et étant fixées à l'un, correspondant, des seconds coulisseaux de raccordement, en formant ainsi une boucle dans chacun des seconds fils d'entraînement ;
un moyen d'entraînement destiné à libérer l'un, choisi, des premiers coulisseaux (17) de raccordement des rainures de blocage, en tendant le premier fil d'entraînement et en faisant ainsi que la première partie d'extrémité et la seconde partie d'extrémité du fil tirent le premier coulisseau de raccordement choisi, contre la force du moyen (18) formant support élastique, en direction du premier élément mobile (14) correspondant, pour déplacer le premier élément mobile correspondant le long de la première rainure de guidage correspondante par un déplacement longitudinal du premier fil d'entraînement lorsque le premier coulisseau de raccordement choisi est libéré ; et destiné à libérer l'un, choisi, des seconds coulisseaux de raccordement des rainures de blocage, en tendant le second fil d'entraînement et en faisant ainsi que la troisième partie d'extrémité et la quatrième partie d'extrémité du fil tirent le second coulisseau de raccordement choisi, contre la force du moyen formant support élastique, en direction du second élément mobile correspondant, et destiné à déplacer le second élément mobile correspondant le long de la seconde rainure de gui-

dage correspondante par un déplacement longitudinal du second fil d'entraînement lorsque le second coulisseau de raccordement choisi est libéré.

4. Appareil de commutation de fibres optiques selon la revendication 3, dans lequel un capillaire (72) est disposé dans chacun des seconds coulisseaux de raccordement, la face d'extrémité d'une seconde fibre optique correspondante étant fixée dans chaque capillaire (72) ; et dans lequel une partie d'extrémité de l'une, choisie, des premières fibres optiques (20) est introduite dans l'un, choisi, des capillaires, lorsque le coulisseau de raccordement supportant la première fibre optique choisie pénètre dans une rainure de blocage et lorsque le coulisseau de raccordement supportant le capillaire choisi pénètre, dans une position en face du premier coulisseau de raccordement, dans une rainure de blocage, en raccordant ainsi optiquement la première fibre optique choisie à la seconde fibre optique fixée dans le capillaire choisi.

5. Appareil de commutation de fibres optiques selon la revendication 4, dans lequel chaque capillaire (72) possède une ouverture d'introduction de forme conique, chaque ouverture d'introduction de forme conique ayant un diamètre interne qui diminue et une surface interne qui est lisse, et dans lequel la face d'extrémité des premières fibres optiques est arrondie.

6. Appareil de commutation de fibres optiques selon la revendication 4, dans lequel la partie d'extrémité de chaque seconde fibre optique est revêtue d'une couche de carbone.

7. Appareil de commutation de fibres optiques selon la revendication 4, dans lequel un film mince de silicone est formé sur chacune des faces d'extrémité des premières fibres.

8. Appareil de commutation de fibres optiques selon la revendication 5, dans lequel la face d'extrémité de chaque première fibre est arrondie par meulage ou par étincelage.

9. Appareil de commutation de fibres optiques selon la revendication 6, dans lequel un film mince de silicone est formé sur chacune des faces d'extrémité des premières fibres.

FIG. 1

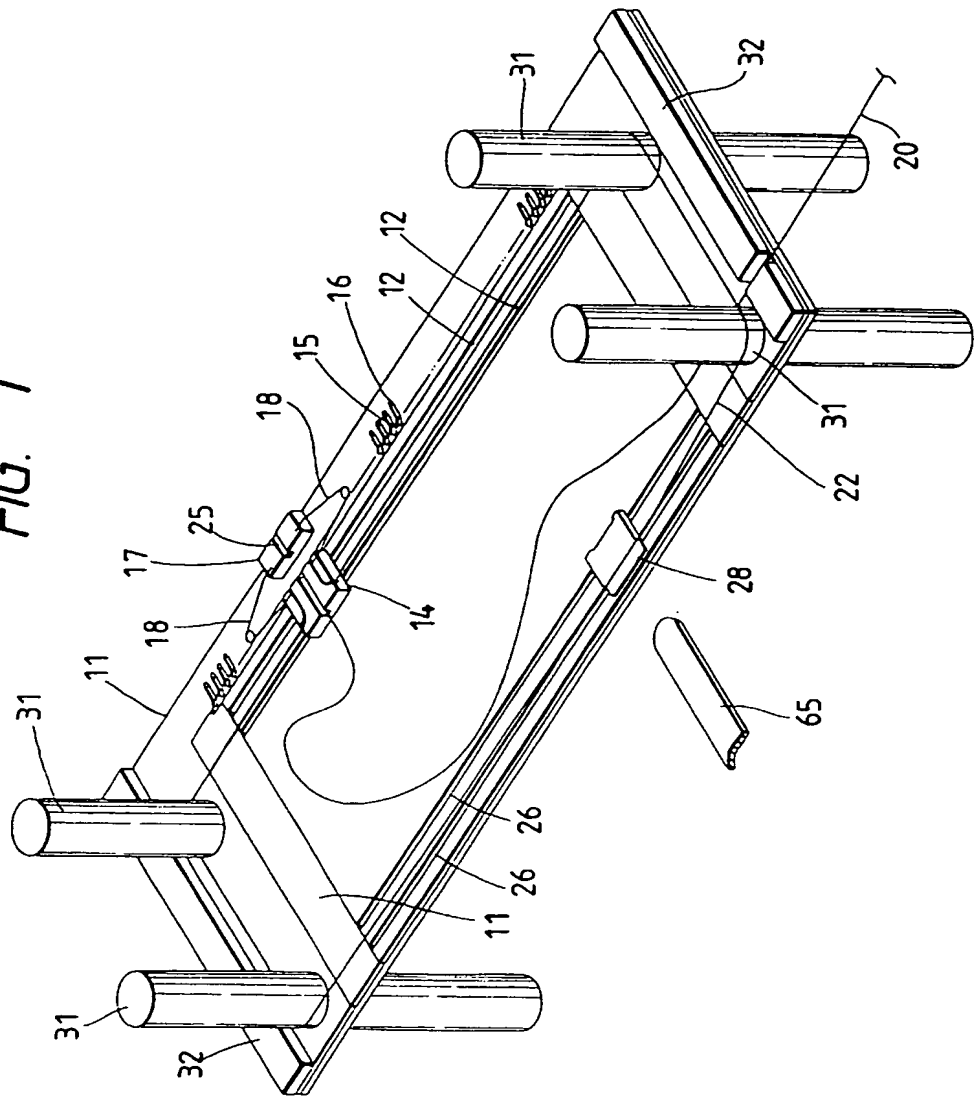

FIG. 2

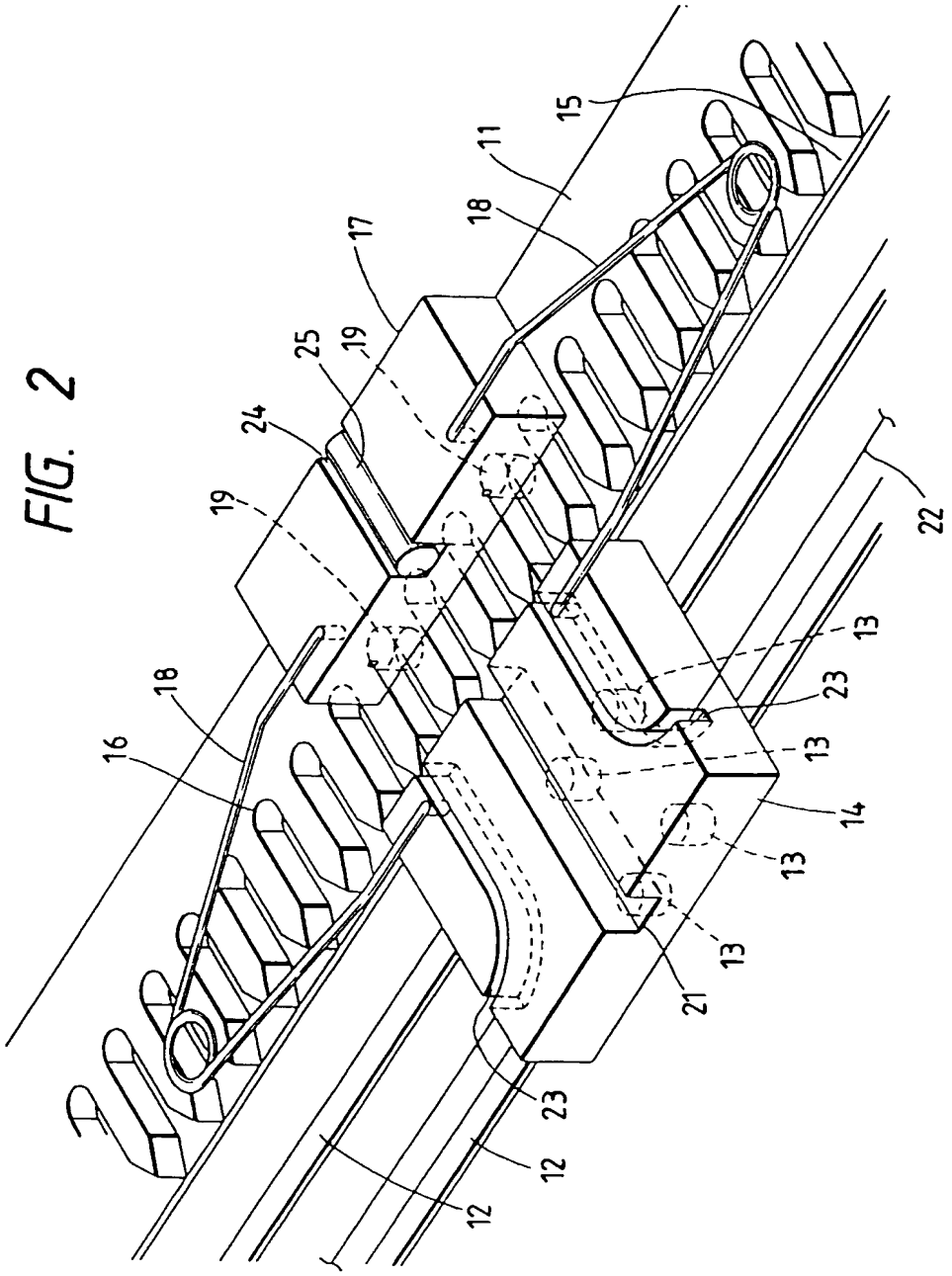

FIG. 3

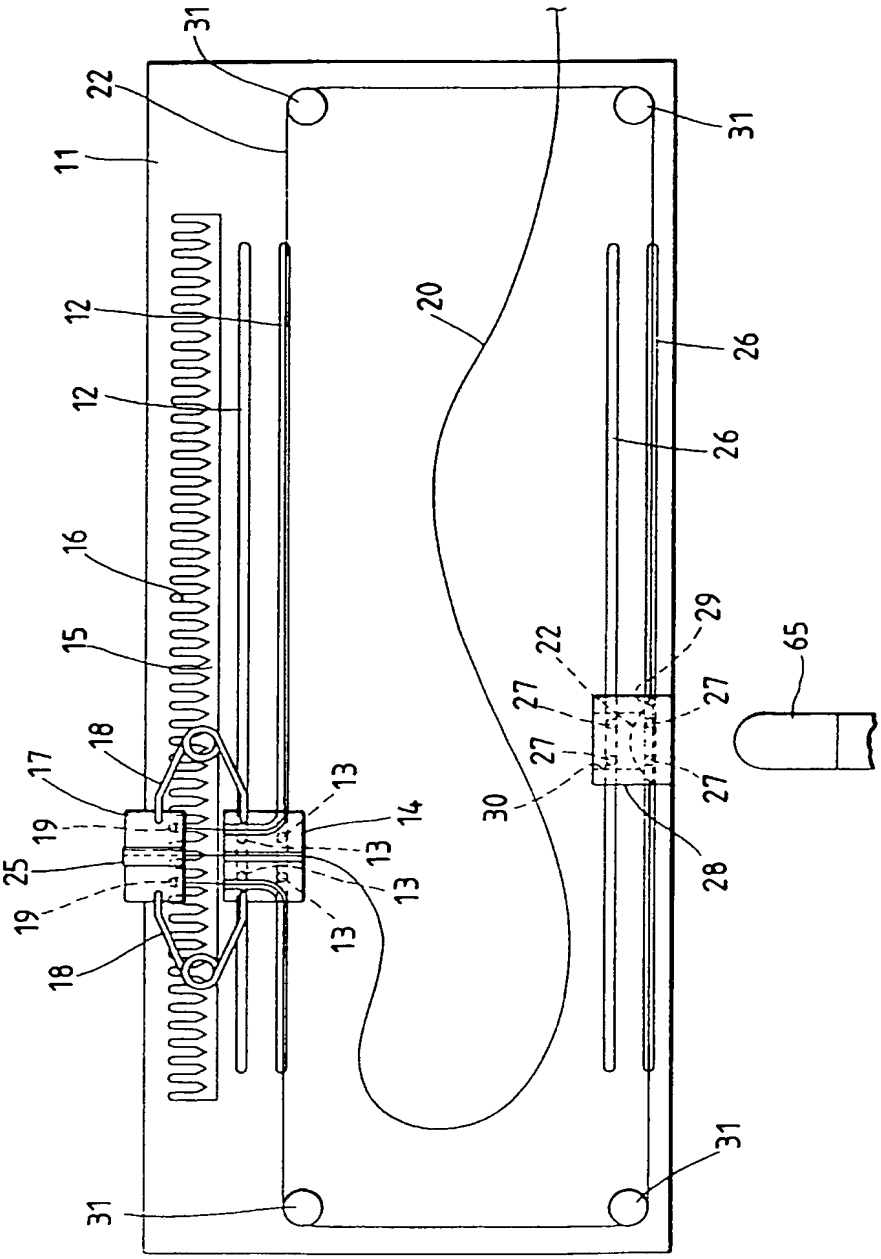
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FIG. 4

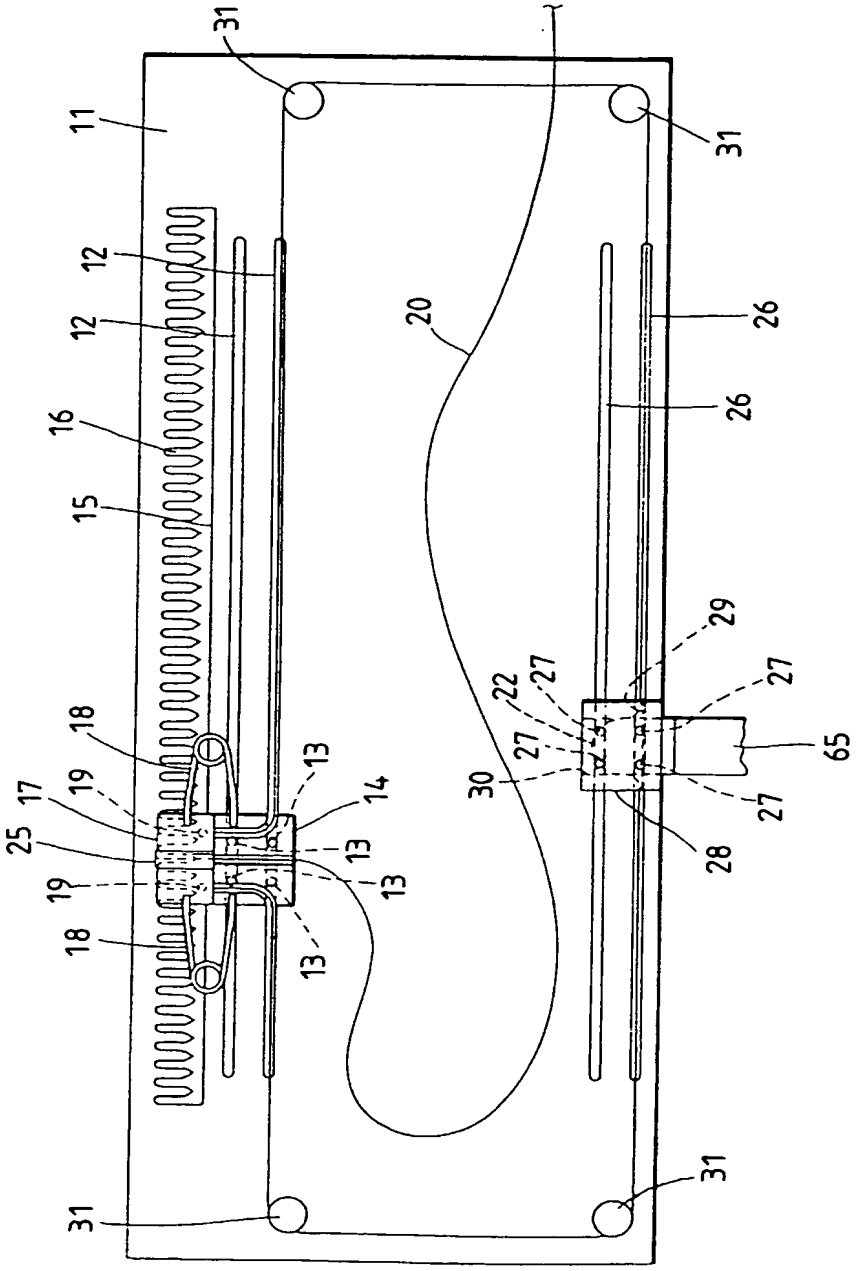
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FIG. 5

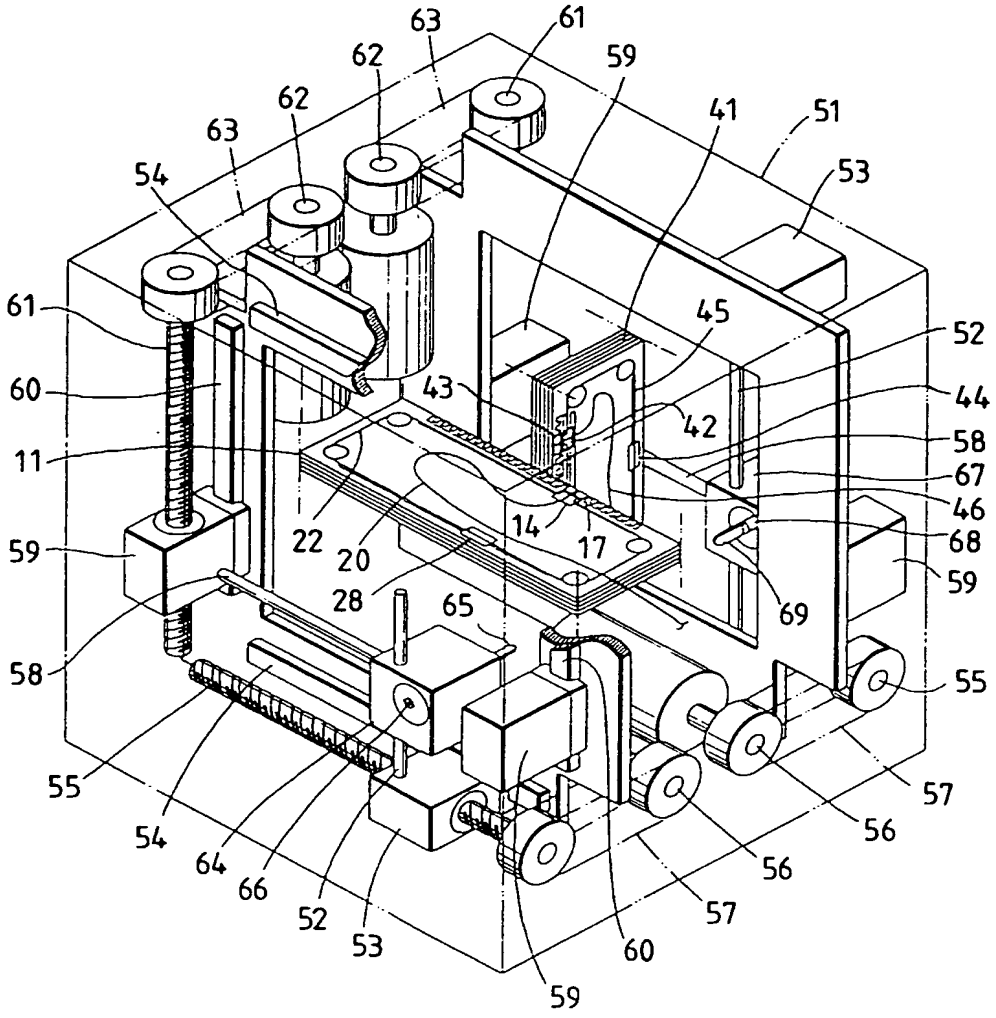
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FIG. 6

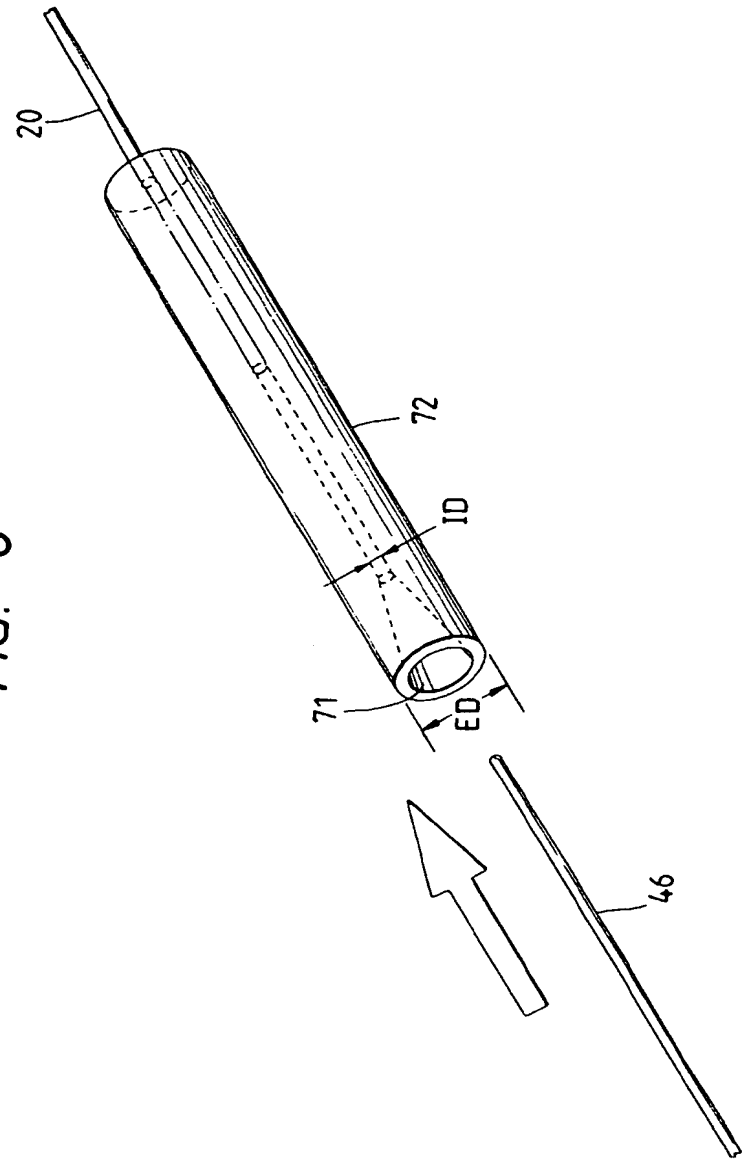

FIG. 7

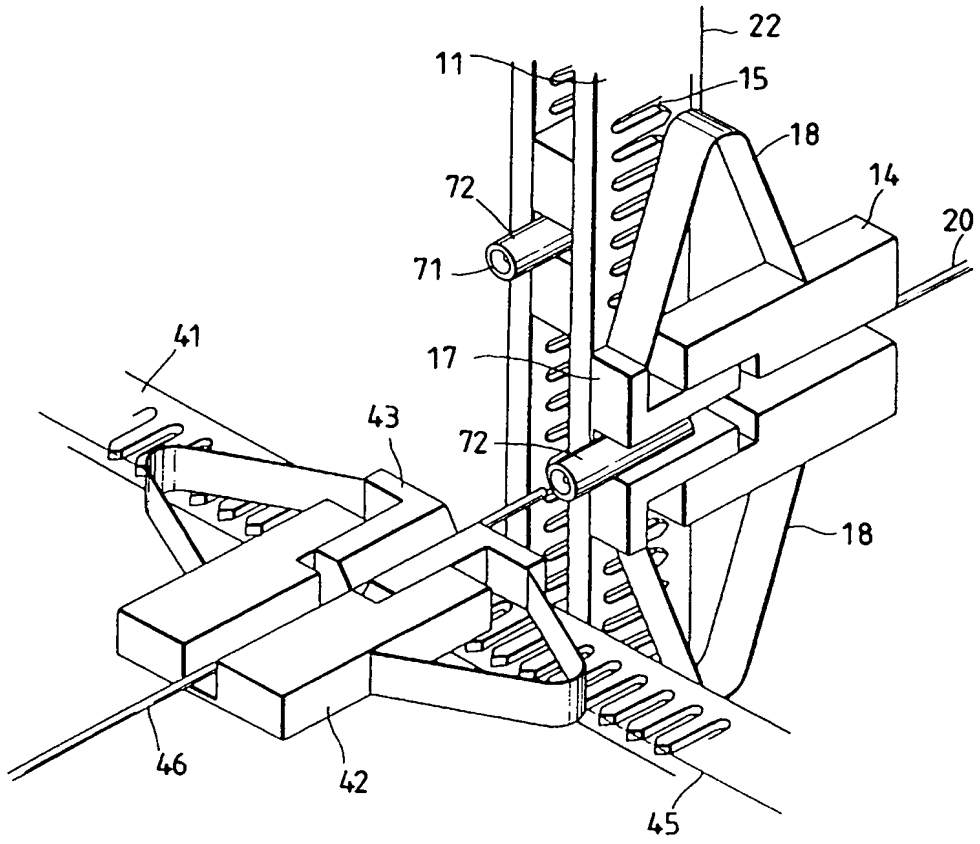

FIG. 8

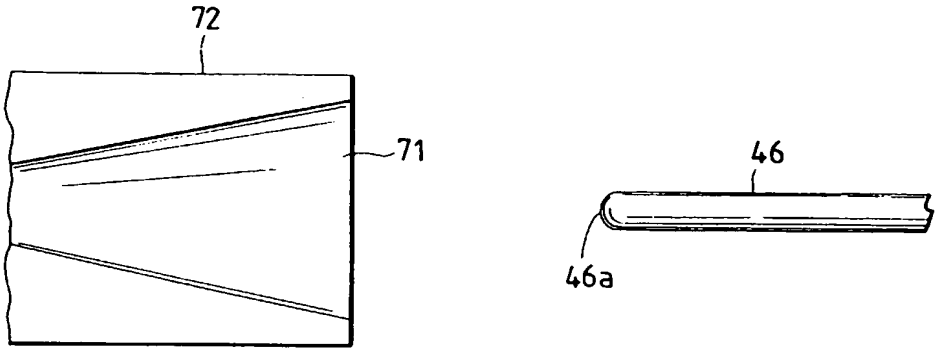

FIG. 9